D. MENTHOL PERCEPTION

1. Introduction of Topics for Discussion

To date, no study has been specifically designed to determine specifications for all RJR mentholated products and sufficient insight into satisfactory menthol loads and deliveries for our products is lacking. Nevertheless, a fair estimate can be made based on a close examination of many past smoker responses. In this section, several studies have been reviewed which have given rise to "best estimates" of menthol load and delivery specifications for RJR mentholated products based on smoker responses to mentholated products in generic 'tar' categories (Table I). These estimates were made considering smoker responses to the attribute menthol taste at an alpha value of 0.1. The Just Noticeable Difference (JND) Study (23) considered smokers responses to the attribute menthol cooling.

2. Background

A large number of menthol perception studies have been completed during the last few years. Each study dealt with specific factors affecting smoker perception of menthol (8,28). Black and Swicegood (1), McKenzie (14), and Perfetti (2,9) explored the effect of aging time on perception of menthol taste. This work led to a specific protocol for analysis and testing of aged mentholated products (3). Perfetti (5, 6, 13) and Mereschak (4) explored the effects of several configurational changes on menthol perception. The results strongly suggested that configurational changes, while keeping delivery of FTC 'tar' constant, have little effect on menthol perception. Several screening studies by Perfetti and Uhrig (7) explored the relationship of the following variables: menthol load (delivery), moisture, humectant ratio (glycerol/propylene glycol), and smoke nicotine (7) to menthol perception. The results of these studies led to the following consumer tests on generic FFLT-M products: an in-house study of Smoke Menthol/Smoke Nicotine (1980) (7) and a consumer study of Smoke Menthol/Pack Moisture (1982) (10). Both tests were designed and ahalyzed using the standard hexagonal RSM format. The most relevant studies to date which directly impact on the subject of this section were performed by Uhrig (11) and Perfetti and Gordin (23). The Uhrig study examined the effect of changes in pack menthol on smoker perception of menthol delivery for cigarettes prepared in the SALEM 85, SALEM Light 85, VANTAGE Menthol 85, and NOW Menthol 85 configurations. The Perfetti and Gordin study examined the JND's for a series of cigarettes prepared in the FF-M (Salem KS), FFLT-M (Salem Lights 84) and the ULT-M (Salem Ultra 85) configurations. A discussion of the pertinent results of all these studies will follow.

3. Perception Studies of Mentholated Cigaretes Based on the Attribute of Menthol Taste

- o FFLT-M Cigarettes

Smoker responses (U.S. Mail Employee Panel) to changes in menthol delivery in the Smoke Menthol/Smoke Nicotine RSM indicated that cigarettes in the 9.5-12.7 mg/cigarette FTC 'tar' range are perceived differently by different smoker categories (FF-M and FFLT-M) (7).

The range of detectable differences for FFLT-M smokers is 0.07 mg/cigarette smoke menthol or approximately 7 ug/puff. For FF-M smokers, the range in smoke menthol is 0.15 mg/cigarette or approximately 17 ug/puff. Smoker responses to changes in menthol delivery from the Smoke Menthol/Pack Moisture RSM (MARC panel)

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indicate that for cigarettes with a pack moisture of 11.5-12.5% and FTC 'tar' of 9.5-10.5 mg/cigarette, FFLT-M smokers perceive a significant difference in menthol taste at approximately the 0.05 mg/cigarette smoke menthol level, or (for the products tested) at a 5-7 ug/puff change (10). Results from the two RSM's appear to be consistent with other data. Uhrig's study (11), which examined the effects of changes in pack menthol on smoker perception of menthol delivery among Research Booth Panel members, indicated that for FFLT-M cigarettes in the SALEM Lights 85 or VANTAGE Menthol 85 configuration a change of about 7 ug/puff constituted a significant difference in menthol taste. This 7 ug/puff difference corresponds to a pack menthol change of 0.09 and 0.13%, respectively, or a change in delivery of about 0.06 mg/cigarette smoke menthol (See Figures 1 and 2).

- FF-M Cigarettes

Uhrig (11) also studied cigarettes prepared in the SALEM KS configuration. Smokers (Research Booth Panel members) perceived a significant difference in menthol taste when the smoke menthol delivery (FTC) changed by approximately 0.11 mg/cigarette or about 13 ug/puff. These changes represent a pack menthol change of 0.08%. (See Figure 3).

- ULT-M Cigarettes

Uhrig (11) studied ULT-M prototypes in the NOW Menthol 85 configuration. Smokers (Research Booth Panel members) were able to significantly detect changes in smoke menthol when a pack menthol difference of 0.18% occured. This equated to a change in smoke menthol delivery of 28 ug/cigarette, or about 3-4 ug/puff (Figure 4). It is interesting that this small change (3-4 ug/puff) is nearly equal to the subliminal levels (~ 2-3 ug/puff) of menthol detection (12).

Mereschak's study (4) of ATG prototypes revealed that for 4-5 mg/cigarette FTC 'tar' prototypes, differences in the range of 0.05 mg/cigarette smoke menthol were easily detected (trained Menthol QDA panelists). However, in her study only two different menthol levels were tested among four prototypes.

- Recommended Brand Specifications for Mentholated Products Based on Attribute of Mentholated Taste

Table II shows the optimum pack menthol for RJR brands that were manufactured from 1981 through 1982. Additionally, the 1981 average (competitive brands) pack menthol data and calculated ship limits (based on levels of menthol variation perceptible to smokers) are shown. (NOTE: Currently there are no formal ship limits for pack menthol or smoke menthol for most of our brands (18)). The average* 1981 pack menthol data for each brand falls well within the control limits for each brand.

The calculated ship limits (based on smoker perceptible differences) for all brands were estimated to be ± 16.3% of the 1981 average pack menthol results. The calculated ship limits for FF-M brands had an upper and lower ship limit of ± 26%, based on the perception of menthol taste of FF-M smokers for similar products. FF-M smokers are less sensitive to changes in menthol taste relative to nicotine delivery for similar 'tar' ranges (7). FFLT-M and ULT-M brands had ship limits of ± 14.5% and ± 13.9% of the average pack menthol results, respectively, because FFLT-M and ULT-M smokers are more sensitive to changes in menthol taste (7).

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Based on the preceding information, it was suggested [illegible] that ship limits for all our mentholated products should generally not exceed ± 14% of the optimum pack menthol. This was a conservative estimate based on few results and calculated perceptible differences of smoke menthol for a wide range of smoker types. This conclusion was presented as a general guideline, subject to revision as work continued in this area and information became more precise.

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*The term 'average' should not be misconstrued. Our products, in general, have a well-defined average pack menthol, based on actual operating conditions, but the pack-to-pack and especially the cigarette-to-cigarette variation is suspected to be quite large (15,16).

o <u>Other Variables Affecting Menthol Taste Perception</u>

As previously mentioned, aging time affects menthol delivery and thus perception (2). Two other important variables affecting menthol perception are moisture (17) and nicotine at particular FTC 'tar' deliveries (1). Smoke menthol delivery (mg/cigarette) is not significantly affected by even large changes in pack moisture (17) (5-12%) (Table III). However, menthol cooling increases with increased moisture at a constant 'tar' and nicotine level (10). For FF-M smokers, nicotine delivery is quite important, because these smokers are much more sensitive to changes in nicotine delivery than they are to changes in menthol delivery at a constant 'tar' level. This was a major conclusion from the Smoke Menthol/Smoke Nicotine RSM. Compared to FF-M smokers, FFLT-M smokers are less sensitive to changes in nicotine and more sensitive to changes in menthol (19,20). ULT-M smokers are sensitive to changes in both smoke nicotine and menthol. These results are not surprising since as air dilution (A/D) is increased to achieve lower 'tar', the ability to make significant changes in smoke nicotine through changes in tobacco blending diminishes. This is particularly true at high A/D levels. On the other hand, menthol applications can easily be increased to compensate for decreased smoke menthol deliveries resulting from increased air dilution. Thus, the required change in menthol application level, such that smokers experience a significant difference in menthol perception, is much larger for ULT products compared to FF-M products (0.18% vs 0.08%), although the sensitivity of smokers evaluating ULT-M products is much greater than those evaluating FF-M products (4 vs. 12 ug/puff).

o <u>Examination of Subliminal Levels of Menthol Delivery on Taste Perception</u>

Two studies have been completed to date examining this aspect of menthol perception (12,27). The threshold level of menthol is in the range of 2-4 ug of menthol per puff. The application level to achieve subliminal perception will vary with configuration. Subliminal levels of menthol are believed to decrease harshness, however, to date this hypothesis has not been adequately tested.

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TABLE I. SUMMARY OF RESULTS OF MENTHOL PERCEPTION STUDIES

Prototype Configuration	Range of % Tobacco Menthol	Estimated Detectable Change (%)	Range Smoke Menthol (mg/cig)	Estimated Detectable change mg/cig	Estimated Detectable change µg/puff	FTC 'Tar' mg/cig	Smoke Nicotine mg/cig
Uhrig's Study (11)							
SALEM 85	0.09-0.42	0.08	A	0.11	12	16.3	1.2
Control	0.30		0.41			16.3	1.2
SALEM Lts 85	0.11-0.49	0.09		0.062	7	11.0	0.88
Control	0.35		0.24			11.0	0.88
VANTAGE M 85	0.42-0.58	0.13		0.066	7	10.8	0.84
Control	0.55		0.28			10.8	0.84
NOW M 85	0.71-1.00	0.18		0.028	4	2.0	0.17
Control	1.05		0.16			2.0	0.17
Menthol/Nicotine RSM (7)							
SALEM Lts 85	0.11-0.75	0.06[B]	0.07-0.62	0.07	8	9.5-12.7	0.6-1.0
		0.15[C]	0.07-0.62	0.15	17	9.5-12.7	0.6-1.0
Menthol/Moisture RSM (10)							
SALEM Lts 85[D]	.51-.85	0.07[B]	0.48-0.77	0.05	5-7	9.5-10.5	
ATG Study (4)							
VANTAGE Ultra			0.27-0.33	0.06	8	3.9-4.9	0.34-0.38
Menthol Perception Study (6)							
SALEM Lts 85	0.36	E	0.20-0.28	.08	9	7.8-8.7	0.65-0.57
SALEM Lts 100	0.26-0.31	E	0.35-0.25	.10	8	12.1-9.4	1.04-0.78

A - Not determined
B - FFLT-M smokers
C - FF-M smokers
D - Moisture range set at 11.5-12.5%
E - No change since smoke menthol deliveries changed because of construction parameters.

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TABLE II. 1981-82 BRAND SPECIFICATIONS FOR PACK MENTHOL

	PACK MENTHOL, %			
FF-M: Brand	Optimum*	1981 Average	Estimated Ship Limits	Difference
SALEM 85	0.30	0.28	0.22-0.40	± 0.08
SALEM 100	0.31	0.28	0.22-0.40	± 0.08
FFLT-M:				
MORE Lt 100 M CPB	0.62	0.54	0.53-0.71	± 0.09
SALEM Lts 85	0.42	0.39	0.36-0.48	± 0.06
SALEM Lts 100	0.55	0.54	0.47-0.63	± 0.08
SALEM Slim Lts 100 CPB	0.62	0.62	0.53-0.71	± 0.09
VANTAGE 85 M	0.47	N/A	N/A	N/A
ULT-M:				
SALEM Ultra 85	0.82	0.86	0.70-0.94	± 0.12
SALEM Ultra 100	0.72	0.72	0.62-0.82	± 0.10
NOW 85 M	1.35	1.35	1.16-1.54	± 0.19
NOW 100 M	1.25	1.17	1.08-1.42	± 0.17
VANTAGE Ultra 85M	0.65	N/A	N/A	N/A
VANTAGE Ultra 100 M	0.77	N/A	N/A	N/A

*All upper and lower control limits have been set at ± 10% of the optimum on a uniform basis.

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TABLE III. MENTHOL DELIVERY WITH CHANGES IN MOISTURE FOR SALEM LIGHTS 85 CONFIGURATION

Pack Moisture, %	Pack (%) Menthol	Pack mg/cig	Smoke Menthol mg/cig	Smoke Menthol ug/puff
4.94	0.36	2.37	0.26	36
5.82	0.38	2.54	0.26	36
6.82	0.31	2.29	0.22	30
7.28	0.37	2.47	0.25	34
9.62	0.34	2.34	0.26	34
11.82	0.35	2.51	0.25	34
12.91	0.32	2.31	0.25	32

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FIGURE 1

PERCEPTION OF CHANGES IN MENTHOL LEVELS FOR SALEM LIGHTS.

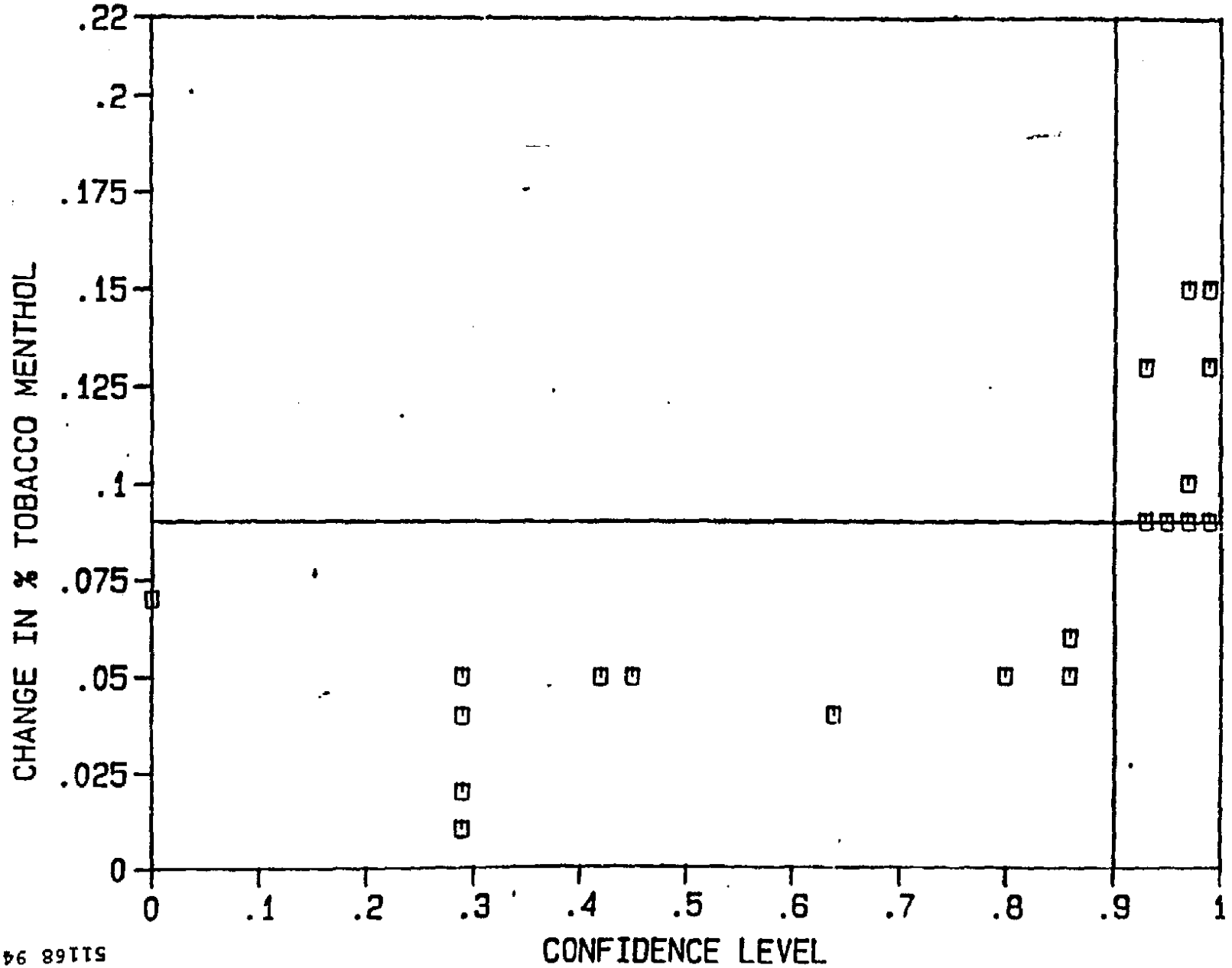

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FIGURE 2

PERCEPTION OF CHANGES IN MENTHOL LEVELS FOR VANTAGE MENTHOL 85.

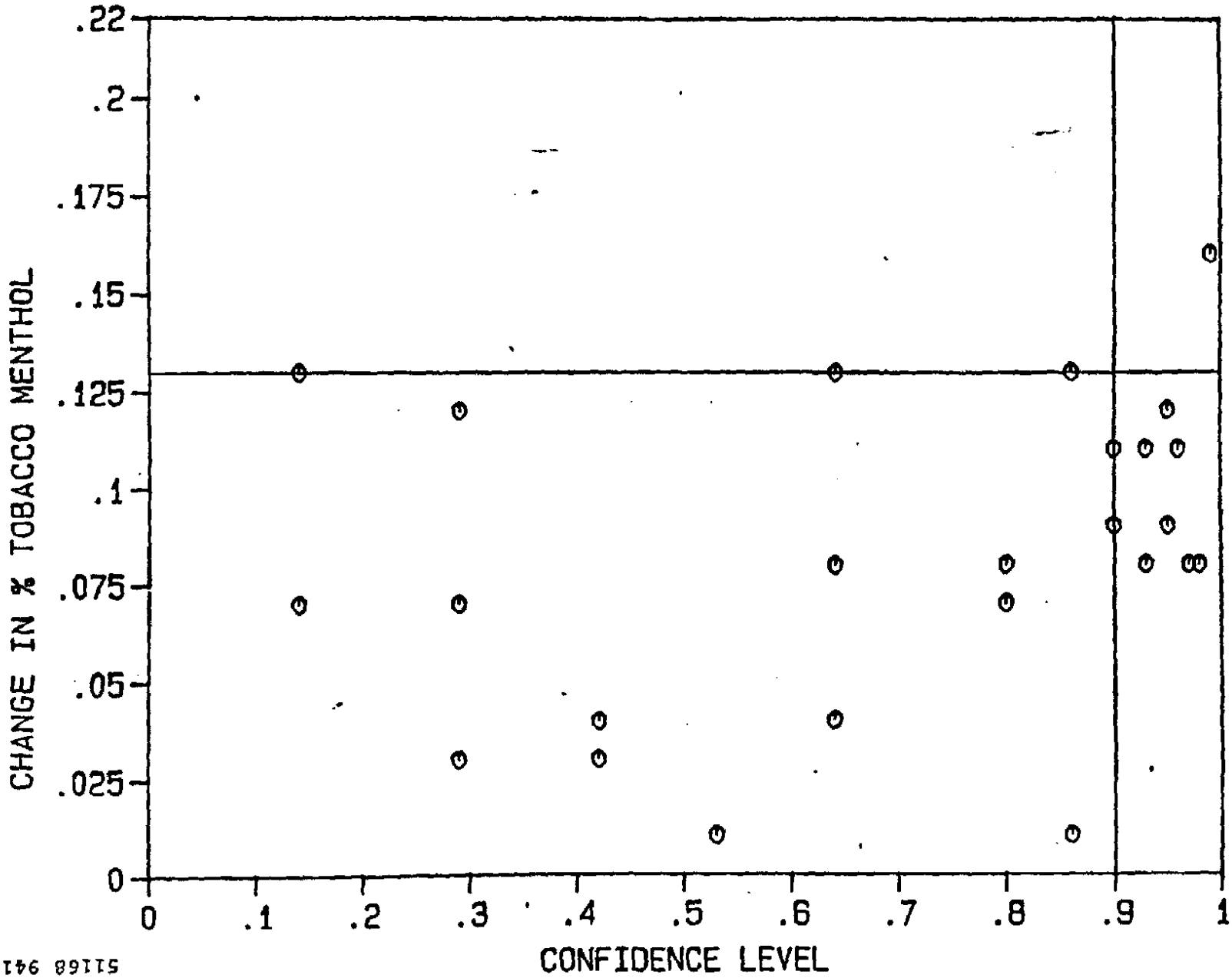

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FIGURE 3

PERCEPTION OF CHANGES IN MENTHOL LEVELS FOR SALEM

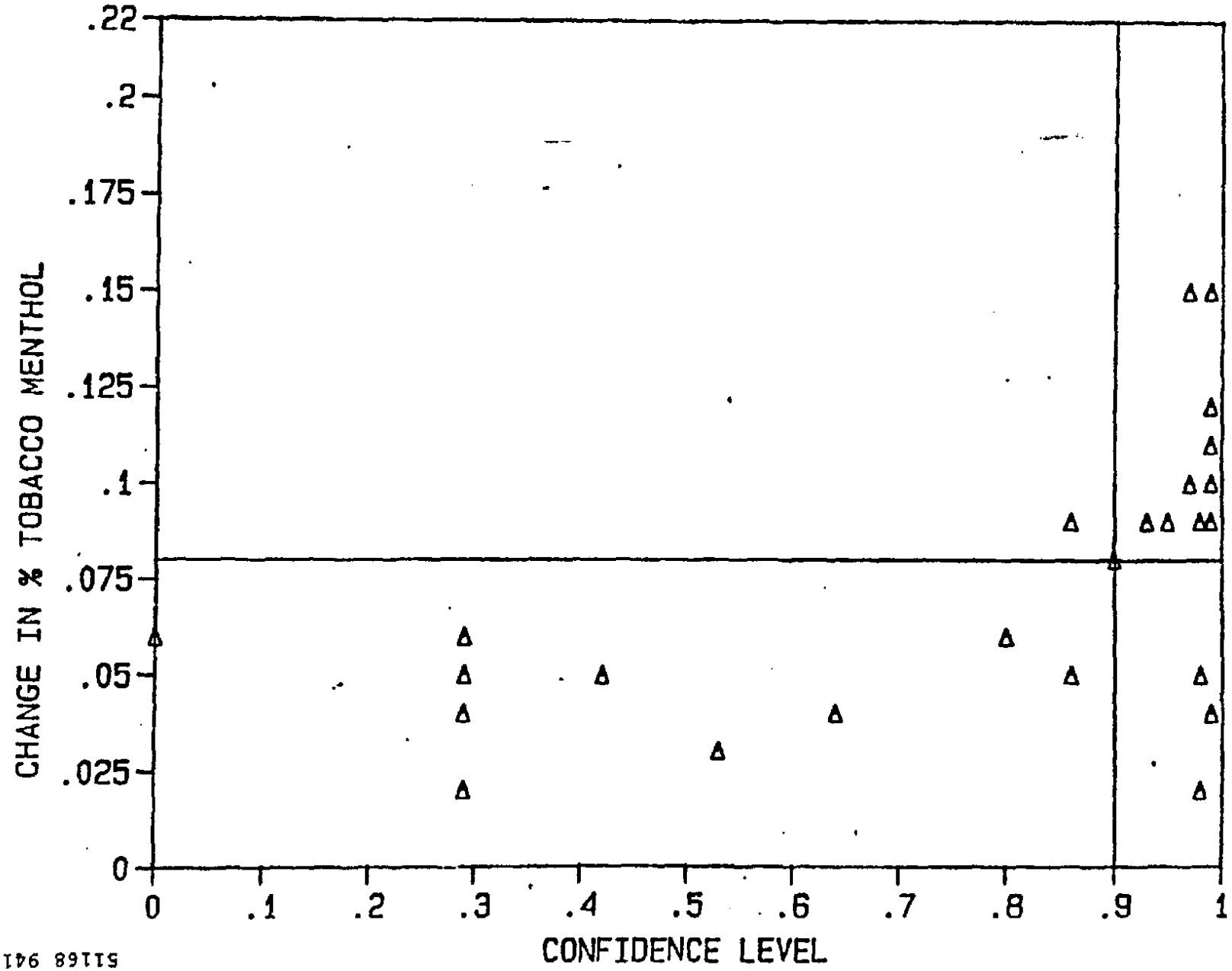

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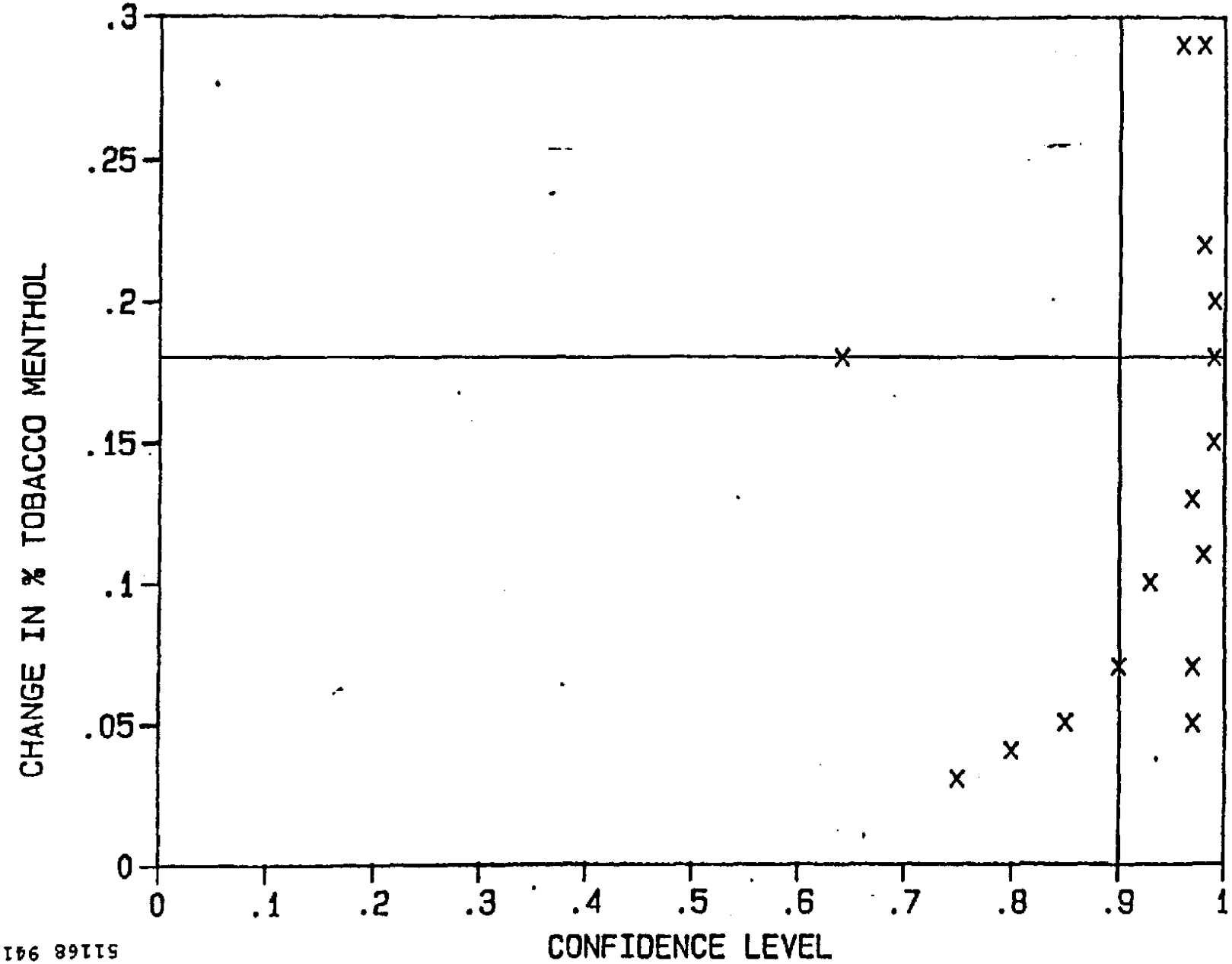
FIGURE 4

PERCEPTION OF CHANGES IN MENTHOL LEVELS FOR NOW MENTHOL.



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- Summary of Results from Perception Studies of Mentholated Product Basedon the Attribute of Menthol Taste

  - The range for pack menthol for FF-M products (>12 mg FTC 'tar') should not be greater than ±0.08% or vary in smoke menthol delivery more than ± 12 ug/puff.

  - FFLT-M products (11-6 mg FTC 'tar') should not vary in pack menthol more than ± 0.09% or have a smoke menthol variation greater than ± 7 ug/puff.

  - ULT-M products (<5 mg FTC 'tar') should not have a pack menthol variation greater than ± 0.18% or a smoke menthol change greater than ± 4 ug/puff.

  - Ship limits should generally not exceed ± 14% of optimum pack menthol.

  - Control limits for pack menthol among all currently produced products fall, on average, well within the above guidelines.

  - Menthol load affects menthol taste perception.

  - Aging time affects the perception of menthol taste.

  - Configurational changes at constant 'tar' levels have little effect on perception of menthol taste.

  - Moisture level variations do not affect perception of menthol taste but do affect the perception of menthol cooling.

  - Changes in plasticizer level and other cigarette additives (e.g. humectants) affect the analytical delivery of menthol and as a result affect menthol taste perception.

4. Perception Studies of Mentholated Cigarettes Based on The Attribute of Menthol Cooling

   - Just Noticeable Difference Studies of Mentholated Products

     Just Noticeable Difference (JND) methodology is used to determine the quantity of change required in a stimulus to elicit a perceptual response. The JND method (24) was applied to mentholated cigarettes in three 'tar' categories (FF-M, FFLT-M and ULT-M, 85mm) to determine the change in % pack menthol and smoke menthol that could be detected by panelists. In this way, realistic manufacturing specifications based on perception of menthol could be determined. The JND for % pack menthol is influenced by configurational changes (26) and blend variations in products. Therefore, separate discontinuous JND's, for cigarettes in the three tar categories, were developed. The constant/stimulus method of product evaluation (24) was employed in this study. Probit analysis and the maximum likelihood solution (25) were the statistical procedures required for data interpretation. A specially trained panel of 15 members was asked to discriminate the difference in pairs of products based on perception of menthol cooling. The JND_{50}, based on perception of menthol cooling for % pack menthol was that change in % pack menthol that 50% of the population could be expected to detect. Similar JND's were determined for smoke menthol because of the high correlation of % pack menthol to smoke menthol in each 'tar' category. Since it was desirable to know when smaller segments of the population could detect a change, a narrower JND was also calculated for each 'tar' category: JND_{10}

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(10% of the population detecting a difference in menthol cooling). The results of the experiments (23) are as follows:

TABLE IV. RESULTS OF JND STUDIES OF MENTHOLATED CIGARETTES

'Tar' Categories	JND_{50}	
	% Pack Menthol	Smoke Menthol (mg/cigt.)
FF-M (0.49, 0.63)*	-0.54/+0.55	-0.84/+0.84
FFLT-M (0.48, 0.43)	-0.27/+0.27	-0.18/+0.18
ULT-M (0.79, 0.31)	-0.51/+0.56	-0.18/+0.18

	JND_{10}	
	% Pack Menthol	Smoke Menthol (mg/cigt.)
FF-M (0.49, 0.63)	-0.27/+0.27	-0.41/+0.41
FFLT-M (0.48, 0.43)	-0.09/+0.09	-0.06/+0.06
ULT-M (0.79, 0.31)	-0.16/+0.18	-0.08/+0.07

*Constant used in each JND Study (%, mg/cigt.)

- Summary of Menthol JND Results

For a particular cigarette configuration there exists a linear relationship between the % pack menthol level and the smoke menthol delivery (mg/cigarette). The results of these experiments have determined the JND 50 and JND 10 limits in % pack menthol and smoke menthol necessary to detect a significant difference in menthol cooling by trained panelists. Manufacturing currently has action limit specifications for % pack menthol to be +/-10% of optimum pack menthol for our mentholated brands. Ship-no-ship limits are arbitrarily set at +/-20% of optimum % pack menthol. Translation of the JND 10 limits for % pack menthol into similar specifications indicate change in menthol cooling would be noted in for perception limits ranging from -60/+60%, -15/+15%, and -22/+25%, respectively. These results indicate that the perceptual limits vary with product 'tar' category, and, most importantly, that our current product specifications are well within the range of % pack menthol levels necessary to detect a significant change in menthol cooling.

Perfetti and Gordin recommended the following:

- Specification limits for RJR mentholated brands should not exceed ± 15% of optimum pack menthol.
- Additional acceptance and attribute testing among consumers, using central location test panels (CLT), should be conducted before more permanent specifications are set.

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Source: https://www.industrydocuments.ucsf.edu/docs/gldj0001

5. Bibliography

1. IOM, A Study of Menthol Migration Within a Cigarette. B. Z. Black and K. W. Swicegood. 12/3/79.

2. Perfetti, T. A., T. J. Steichen, G. A. (Armendarez) Ryan and M. D. Wallace. Menthol Delivery and Perception. R&DM, 1982, No. 3. 2/3/82.

3. IOM, Mentholated Cigarettes Protocol. F. A. Thacker, Jr.. 3/24/82.

4. PDT Test Report, No. 48, ATG Study. C. S. Mereschak. 4/2/82.

5. IOM, Unique Filter Configurations on SALEM Lights 63 mm Rods - RBP Results. T. A. Perfetti, M. S. Uhrig, to R. A. Lloyd, W. M. Henley and C. L. Neumann. 10/10/80.

6. IOM, Menthol Perception Study - Final. T. A. Perfetti and G. W. Worrell, to R. A. Lloyd. 2/25/81.

7. IOM, Top Line Summary on Menthol Studies to Date on FFLT Menthol Prototypes. T. A. Perfetti and M. S. Uhrig, to W. M. Henley. 11/4/80.

8. IOM, Review of Factors Affecting Menthol Migration and Smoke Menthol Transfer. T. A. Perfetti to R. A. Lloyd and C. L. Neumann. 5/18/81.

9. Perfetti, T. A., Study of the Migrational Distribution and Freezer Storage of Mentholated Products. R&DM, 1982, No. 2. 1/25/82.

10. Perfetti, T. A. and E. Hardman. FFLT-M 85 mm Moisture/Menthol Consumer Acceptance Study. R&DM, 1982, No. 28. 7/7/82.

11. Unpublished data, but noted in 2nd Quarterly Report, 1980, W. M. Henley.

12. Estimation of subliminal levels of menthol delivery was possible from examination of sensory results from Project N.C. and from recent analytical data collected by Dunn and Gordon. IOM, Low Levels of Menthol in Smoke. B. Dunn and B. M. Gordon to D. A. Garnett. 4/2/82.

13. IOM, QDA Paneling of Mentholated Dual-Filtered vs. Conventional Filtered Cigarettes. T. A. Perfetti to R. A. Lloyd and C. L. Neumann. 7/7/81.

14. IOM, Menthol delivery from Aged Cigarettes. J. L. McKenzie to B. E. Winfrey. 4/27/73.

15. IOM, Correlation of Draft and Dilution Variables to Selected Smoke Analysis Variables. T. J. Steichen to J. W. Mabe. 11/1/79.

16. IOM, Indirect 'Tar' Control Study. T. J. Steichen to R. L. Morgan. 9/30/80.

17. Green, C. R., F. W. Conrad, M. F. Dube, J. L. Harris, A. L. Angel. Dry Cigarette Chemistry. R&DM, 1982, No. 5. 4/2/82.

18. IOM, D. A. Calleson to Directors. Mentholated Cigarettes: An Overview of RJR Methods and Procedures. 3/23/82.

19. Green C. R., T.A. Perfetti, P. P. Mangan and C. J. Mereschak. Nicotine to Menthol Ratio. R&DM, 1983, No. 16. 4/12/83.

51168 9416

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Source: https://www.industrydocuments.ucsf.edu/docs/gldj0001

20. Green, C. R., T. A. Perfetti, P. P. Mangan and C. J. Mereschak. The Relative Importance of Smoke Menthol and Nicotine in the Organoleptic Perception of FFLT Mentholated Cigarettes. R&DM, 1983, No., 74. 12/15/83.

21. IOM, Study of the Effect of Plasticizer Level on Smoke Menthol Delivery and Perception. T. A. Perfetti, C. J. Mereschak and G. W. Warrel to W. L. Clapp. 9/1/83.

22. Perfetti, T. A., Specifications on Mentholated Cigarettes Based on Perception-Studies. R&DM, 1982, No. 33. 7/21/82.

23. Perfetti, T. A., and H. H. Gordin. Just Noticeable Defference Studies of Mentholated Products. R&DM, 1983, No. 76. 12/19/83.

24. Jones, L. V., Methodology of Preference Measurement; Chapter II. Report P-1101, Rpt. #4, Quartermaster Food and Container Institute for the Armed Forces, Research and Engineering Command, Quartermaster Corps., U.S. Army, Chicago, Illinois, September 30, 1957.

25. Finney, D. A., Probit Analysis: A statistical Treatment of the Segmoid Response Curve. Second Edition. Cambridge Press, 1962.

26. Norman, A. B., T. A. Perfetti, M. E. Poe and J. B. Newsome. The Effects of Cigarette Construction Parameters and Menthol Load on Menthol Cigarette Performance. R&DM, 1984, No. 59. 9/5/84.

27. Harllee, G. C. J. D. Woods and G. W. Worrel Effect of Sub-Threshold Levels of Menthol on WINSTON Cigarettes. R&DM, No. 27, 1974. 12/27/74.

28. IOM, Menthol Technology: Delivery, Transfer, Perception. T. A. Perfetti to D. A. Calleson. 2/22/82.

51168 9417

PM3006574821

Source: https://www.industrydocuments.ucsf.edu/docs/gldj0001